CIRCULAR NO. 131 OCTOBER, 1930
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

UTILIZATION OF BLACK LOCUST

By JOHN B. CUNO

Associate Wood Technologist, Forest Products Laboratory, Branch of Research, Forest Service

CONTENTS

INTRODUCTION

The wood of black locust, *Robinia pseudoacacia*, is used chiefly for insulator pins, wagon hubs, treenails, fence posts, and mine timbers. For these uses it is admirable because of its hardness, strength, and durability. A valuable characteristic of the tree is its rapid growth on many types of soils during the first 20 to 30 years of its life. This rapid growth and the extensive network of roots developed by black locust make it well suited for planting to check erosion.

The greatest obstacle to more extensive cultivation and utilization of black locust is the locust borer, *Cyllene robinae*, a black or brown and yellow-striped, long-horned beetle that attacks small trees and riddles the wood. The numerous holes that it makes may render the wood valueless and often so weaken the trees that they are easily broken by the wind. The damage from the borer has not been nearly so serious in the West as in the East.

Under some conditions,[1] plantations of black locust may be at least partly protected from the borer if the locusts are planted in thick stands or so mixed with other trees as to produce dense shade. So grown they are more apt to be free from locust attacks and will early drop off their lower branches and develop clean, straight poles during the first 10 to 15 years of growth.

[1] See the following publication: CRAIGHEAD, C. F., PROTECTION FROM THE LOCUST BORER. U. S. Dept. Agr. Bul. 787, 12 p., illus. 1919.

THE TREE

Seven or eight species of the genus Robinia grow in the United States and Mexico, and three are found in the United States in tree form. Of these black locust is the most valuable, New Mexican locust (*Robinia neo-mexicana*) second in importance, and clammy locust (*R. viscosa*) third. New Mexican locust grows in New Mexico, Arizona, Utah, and Colorado. Clammy locust was originally confined to the mountains of North Carolina and South Carolina. It has, however, been planted extensively and has spread from plantations. The wood of New Mexican locust and of clammy locust is quite similar to that of black locust. Black locust is popularly known as yellow locust under certain conditions, specifically when it is found on slopes and mountain coves in larger groups than in the bottom lands, where the trunks are characteristically long and straight.

The wood of black locust is sometimes confused with that of honeylocust, waterlocust, and Texas honeylocust. These three species, whose wood is quite similar, belong to the genus Gleditsia—an entirely different group from the genus Robinia. Honeylocust (*Gleditsia triacanthos*) is not the equal of black locust in strength properties or durability. It is somewhat used for planing-mill products and boxes and crates. Waterlocust (*G. aquatica*) and Texas honeylocust (*G. texana*) have but slight use.

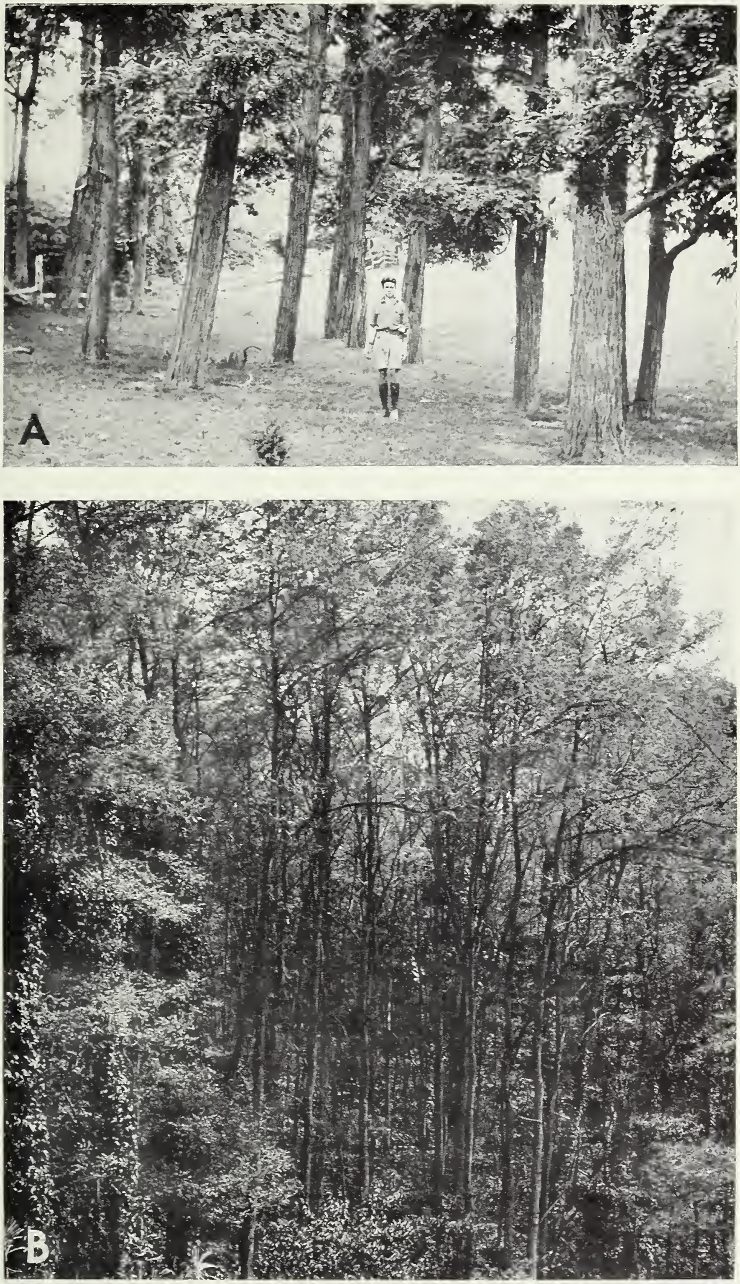
Black locust trees ordinarily reach a height of 40 to 80 feet and a diameter of 1 to 2 feet, with comparatively long, straight stems and small crowns in dense forest growth (pl. 1, B) and longer and more spreading crowns in the open (pl. 1, A).

RANGE

The natural range of black locust (fig. 1) is believed to have been restricted originally to the Appalachian Mountains from Pennsylvania to Georgia, and to certain portions of Arkansas and eastern Oklahoma. The tree reaches its best development on the western slopes of the Appalachian Mountains in West Virginia. It has been widely planted and is found in practically every State in the Union in plantations, fence rows, or in the forest. While black locust is much more common in the East than in the West, it has, however, been grown successfully in the irrigated valleys of Utah, Idaho, and eastern Oregon and Washington. Plantations in Utah and Washington have been among the most successful in the United States.

HABITS AND GROWTH

Black locust grows best in a deep, well-drained fertile loam, but will grow in almost any soil except one that is very sandy or wet, heavy, and acid. On limestone soils it usually attains an excellent development. In its natural range black locust is found along streams or singly and in groups on the slopes, and in the coves of the mountains, and often on the borders of forests. On slopes and in coves its principal associates are black, red, and chestnut oaks, chestnut, pignut hickory, and maple. Along streams locust grows with ash, maple, black walnut, and other trees. On burned-over forest land it often grows in pure stands.



A, A pure stand of thrifty black locust in the mountains of Bedford County, Va. These trees if not cut too soon will make splendid insulator pin material; B, a group of black locust trees on a Long Island farm

An examination of 50 black locust trees in various locations, the oldest 83 years of age, showed that the rate of growth increased rapidly up to 25 or 30 years of age, after which it decreased. The fastest growth noted was at the rate of about 1¾ inches in diameter per year, while the slowest was only 1 inch in 25 years. The rings of average merchantable timber ranged in width from one-tenth to one-fourth of an inch. The sapwood was narrow, generally less than one-half inch in width, and contained on the average four annual rings.

FIGURE 1.—Natural and commercial ranges of black locust

REPRODUCTION

Black locust ordinarily reproduces itself abundantly by seeds and by stump and root sprouts. Where it is desired to set out a plantation 1-year-old seedlings are recommended as the most economical and ordinarily the most successful. These seedlings the planter can either grow for himself or purchase from State and private nurseries. Where seedlings are grown, the seed, gathered locally or purchased, should be soaked in warm water not over 160° F. from 8 to 12 hours and then should be sowed immediately and to a depth of 0.5 inch. Spring sowing is preferable.

ANNUAL CUT AND PRESENT SUPPLY

Only the most general estimates of the annual cut (Table 1) and present supply of black locust are available. Table 2 is based largely on information secured in connection with an investigation made during the World War at the time when locust treenails were needed in large quantities for building ships.

TABLE 1.—*Estimated annual cut of black locust in the United States, 1926*

Product	Quantity [1]
	Cords
Fence posts	20,000
Insulator pins and cobs	18,000
Mine timbers	2,725
Wagon hubs	1,000
Poles	350
Total	42,075

[1] Dealers generally figure 400 board feet to the cord for black locust bolts although a cord of wood ordinarily is considered to contain 500 board feet.

TABLE 2.—*Estimated stand of commercially important black locust timber, 1926* [1]

State	Estimated stand	Approximate percentage of total stand of black locust in various States	State	Estimated stand	Approximate percentage of total stand of black locust in various States
	Cords	*Per cent*		*Cords*	*Per cent*
Tennessee	280,000	22.0	Georgia	20,000	1.5
Kentucky	250,000	20.0	Ohio	20,000	1.5
West Virginia	200,000	16.0	All other States	150,000	12.0
Virginia	175,000	14.0			
North Carolina	100,000	8.0	Total	1,255,000	100.0
Pennsylvania	60,000	5.0			

[1] Corrected to 1926 from an informal survey made during the World War.

The stand of black locust so varies on different forest areas that it is not practicable to assign a definite average amount per acre, but an idea of the stand may be approximated by saying that—

One acre might occasionally contain 20 cords.

Ten acres that contain an average of 10 cords per acre would be considered to have a very good yield.

One hundred acres that contain an average of 5 cords per acre would be exceptional.

One thousand acres that contain an average of 1 cord per acre would be very unusual.

A tract of 50 acres in the western part of Virginia in 1926 yielded 450 cords of locust or 9 cords per acre. This was an exceptionally good stand. Another tract of 200 acres in Botetourt County, Va., yielded 270 cords of black locust. This was a heavy yield for so large an area.

CUTTING AND MARKETING

The value of black locust stumpage varies considerably, depending upon the character of the stand, whether dense or scattering, the quantity and accessiblity of the timber, and its size and quality. Where a large quantity of timber can be cut in one locality, the logs or bolts can generally be purchased for less than where the trees are scattered over a large area.

Stumpage values range from $1 per cord to as high as $7 per cord, the average being around $4. These figures represent actual outright purchases of standing timber.

Round black locust is purchased by one of three common methods. Under the first method it is bought by the manufacturer from nearby farmers who cut and haul it direct to the manufacturer's plant. (Pl. 2, A.) This method is simple and direct.

Under the second method users of locust send their buyers throughout the sections where black locust may be found in quantity and have them arrange for the purchase of bolts either delivered to the manufacturer's plant or hauled to a railroad siding from which shipment to the plant is made in box and cattle cars. The buyers are generally paid on a commission basis for the amount of locust they purchase, or are paid a salary and a commission.

The third method, that of purchasing stumpage and hiring local labor to cut, haul, and load the material, although requiring considerable overhead expense, has the advantage of insuring a more constant supply of material, and material that is generally better in quality than that hauled to mills by farmers or that purchased by commission men because the cutting can be more closely supervised. If the locust is found in considerable quantity over a fair-sized area, this method is quite satisfactory, since crews of experienced men can be steadily employed and the work can be conducted much as an ordinary logging job.

Two men can fell and buck 2 to 3½ cords a day. One and one-half cords per man per day is a good average for experienced choppers working in better than average locust. A cord per man per day is more nearly a general average for the whole field. The wage paid to choppers in Virginia in 1926 was generally from $2 to $2.75 per day.

In general, locust bolts are bought in lengths not less than 4 feet 2 inches, and seldom more than 8 feet 4 inches. Occasionally good bolts 3 feet or 10 feet in length will be taken. Choppers are expected to cut such lengths to eliminate the worst crooks in the trees. Bolts from large trees are preferred to those from small trees. Although 128 cubic feet to a cord is the prevailing measure, cords of locust often average 130 cubic feet to allow for loss from slant bucking and waste from cut-off saws.

Cordwood is paid for on the basis of 128 cubic feet to the cord of bolts as piled on the ground or loaded on a wagon. (Table 3.) Deductions are made for crooked or irregular pieces, for different lengths in the same pile, and for defective wood. (Pl. 2, B.) Fifteen dollars per cord was the average price delivered at the manufacturing plant in 1926 for black locust bolts. Where purchase is made on a piece basis, the length and the diameter of each stick at the top, inside the bark, are measured.

TABLE 3.—*Prices paid in Virginia for bolts 8 feet 4 inches long of good-quality material, 1926*

Diameter,[1] inches	Price	Diameter,[1] inches	Price	Diameter,[1] inches	Price
5	$0.25	11	$0.85–$1.75	17	$2.35
6	$0.30– .50	12	1.00– 2.00	18	2.75
7	.35– .75	13	1.15– 2.25	19	3.25
8	.40– 1.00	14	1.35– 2.50	20	3.75
9	.50– 1.25	15	1.65	21	4.25
10	.65– 1.50	16	2.00		

[1] Diameters are for small end of log inside bark.

The high percentage of defective wood, the small diameters, and the short lengths usually cut preclude the purchase of locust on the basis of log scale. The weight of a locust delivery is often used as a rough check upon its volume, especially in car shipments. A weight of 5,000 pounds per cord in an unseasoned condition is considered a fair average.

TABLE 4.—*Items making up cost of a cord of black locust delivered at manufacturing plants, Virginia, 1926*

Item	Low	High	Average
Stumpage	$1.00	$7.00	$4.00
Cutting and bucking	2.50	2.50	2.50
Bunching, piling, and hauling to railroad	2.50	6.50	4.50
Loading on cars	.50	.50	.50
Railroad freight	1.50	5.50	3.50
Total, delivered at mill	8.00	22.00	15.00

The claim is made by most manufacturers that it is unprofitable to manufacture insulator pins under present conditions if the raw material costs more than $15 per cord. (Table 4.)

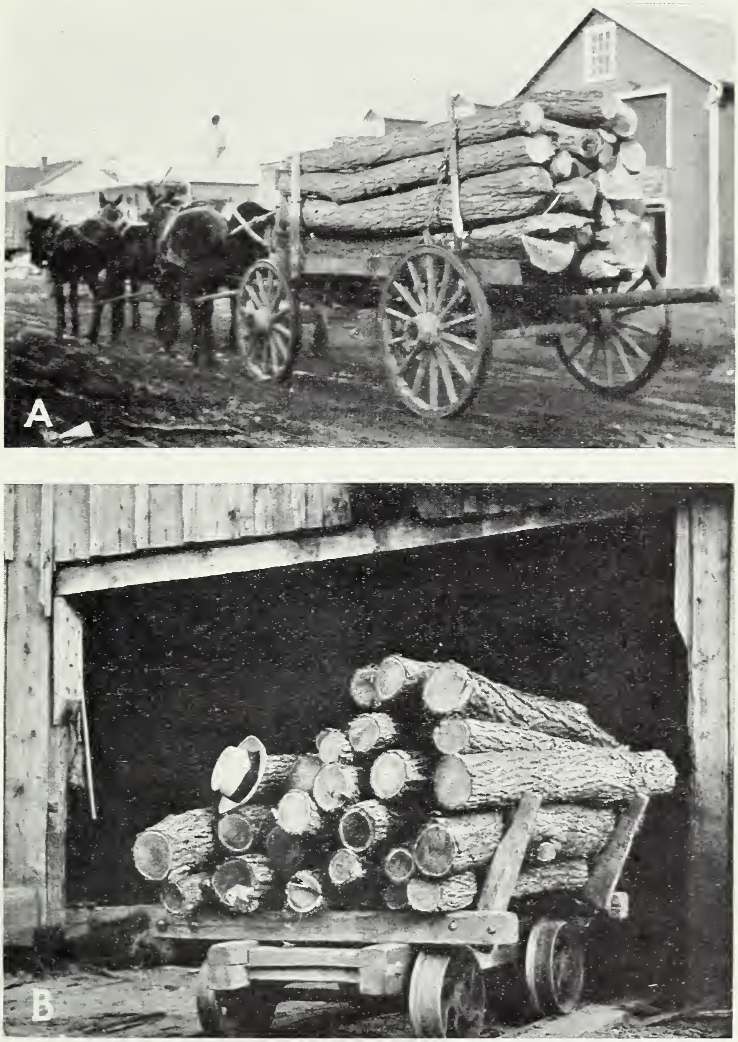
THE WOOD

APPEARANCE

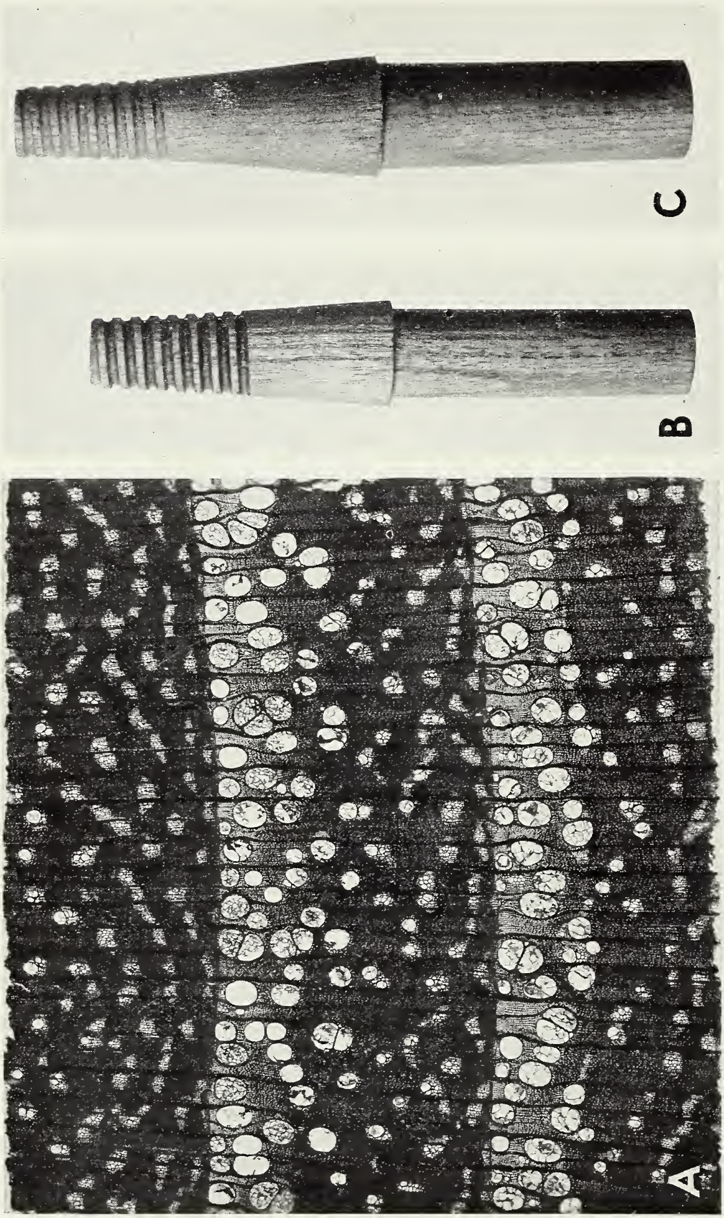
The sapwood and heartwood in mature black locust trees present a striking contrast. The sapwood is creamy white and forms a thin band around the darker heartwood, from which it is sharply distinct. The heartwood when freshly cut varies from a greenish yellow to a dark brown and is very seldom alike in any two places. After exposure to the air it becomes russet brown. The wood of black locust is often confused with that of Osage-orange (*Toxylon pomiferum*). The two woods can, however, be distinguished by using a wet cloth. When applied to black locust the cloth will not discolor appreciably, but when applied to Osage-orange it will turn yellow. Osage-orange also often has reddish streaks not found in black locust.

STRUCTURE

Black locust is a ring-porous wood. (Pl. 3, A.) In other words, the pores are comparatively large in the inner portion or spring wood of each annual ring. In the heartwood the pores have become



A, A load of black locust grown in the mountains and hauled direct to the mill; B, many of these black locust bolts cut for insulator pins are too small for profitable manufacture



A, Cross section of the wood of black locust highly magnified; B, insulator pins commonly used for telephone lines, $1\frac{5}{8}$ by 8 inches; C, pins commonly used for electric-light lines, $1\frac{3}{4}$ by 9 inches

plugged with a growth known as tylosis which causes them to appear on a cross section as a light-colored band rather than as a porous ring. Under a hand lens it can be seen that this band is the width of two or three rows of pores. In the summer wood, that is, the wood in the outer portion of each annual ring, the individual pores are very small.

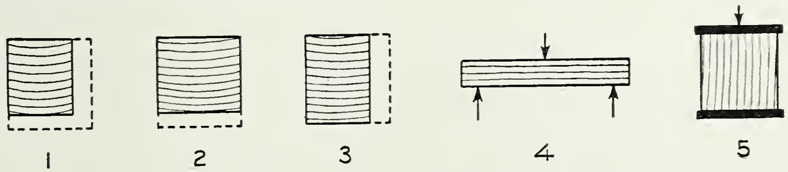
PROPERTIES

Black locust is one of the heaviest and hardest of our native woods. It ranks very high in shock-resisting ability and strength and has a moderately small shrinkage. It is mostly straight grained and without a distinct odor or taste. The actual and comparative properties of black locust are given below:

Actual and comparative properties of black locust wood

Locality where grown	Tennessee
Weight per cubic foot:	
Green ... pounds	58
Air-dry ... do	49
Kiln-dry ... do	48
Specific gravity, oven-dry, based on volume when green	0.66
Shrinkage from green to oven-dry condition:	
In volume (1) ... per cent	9.8
Radial (2) ... do	4.4
Tangential (3) ... do	6.9
Comparative shrinkage (twice volume plus radial plus tangential divided by 3) ... per cent	10.3
Strength in bending at 12 per cent moisture: (4)	
Modulus of rupture ... pounds per square inch	19,400
Relative strength compared with white oak (white oak=100)	128
Strength in compression parallel to grain at 12 per cent moisture: (5)	
Maximum crushing strength ... pounds per square inch	10,250
Relative strength compared with white oak (white oak=100)	138
Composite values:	
Strength as a beam or post	16,180
Compared with white oak (white oak=100)	163
Hardness	1,610
Compared with white oak (white oak=100)	149
Shock-resisting ability	17.0
Compared with white oak (white oak=100)	134
Stiffness	2,200
Compared with white oak (white oak=100)	145

NOTE.—Each of the composite values given in this table is a weighted average of several values derived from different kinds of strength tests. For instance, strength as a beam or post is a combination of values derived from tests in static bending, impact bending, and compression parallel to grain.



1=in volume; 2=radial; 3=tangential; 4=strength in bending; 5=strength in compression parallel to grain

The heartwood is extremely durable in the ground. The sapwood decays rapidly. Fortunately the sapwood is thin and forms only a small part of the useful volume of the log.

The defects common in black locust are wormholes, knots, splits, cross grain, decay, and bird pecks. Bird pecks mar the wood only by the discoloration that follows, but the other defects may weaken it and are the cause for the rejection of considerable material. Checking and splitting in black locust generally occur in only a moderate degree.

UTILIZATION

INSULATOR PINS

The largest industrial use in the United States for the black locust is for making insulator pins. Approximately 18,000 cords of the highest quality timber available is cut each year for this purpose; from this approximately 25,000,000 pins are manufactured, largely by small mills, for both domestic and foreign use. Insulator pins are exported to Europe, South America, Australia, Africa, and the Hawaiian Islands.

A wooden insulator pin (pl. 3, B and C) is a turned product, one end of which is tapered and threaded, and the other end very slightly tapered and turned smooth. The pins are inserted in the cross arms of telephone and transmission lines to support the glass or porcelain insulators to which the wires are fastened. The insulator is screwed to the threaded end of the pin, and the cross arm receives the smoothly turned or lower part of the pin, the shoulder of the pin resting on the top of the cross arm. A nail driven through the side of the cross arm at the center line into the shank of the pin holds it and prevents it from turning or pulling out.

The most common insulator pin is the one manufactured for signaling lines (pl. 3, B) and is 8 inches in length and 1⅝ inches in diameter at the widest place. This is the pin most widely purchased by the telephone companies of the United States and other countries. Some fourteen million to fifteen million 8-inch telephone pins are manufactured from black locust each year.

The next most common insulator pin is 9 inches in length and 1¾ inches in diameter at the widest place. It is used by electric-light companies. Seven million to eight million such pins are produced annually in the United States. Approximately 3,000,000 insulator pins, larger than the electric-light pin, are produced for the use of electric-railroad and power companies in transmitting power.

Small quantities of especially turned and threaded products called cobs or tops (pl. 4, A) are made of black locust. The larger of the two, which is used on electric-light lines of minor importance, is made from locust blocks approximately 2¼ by 2¼ by 4¾ inches. The small cob, the standard for telegraph lines, although usually of oak, is sometimes made from locust left over from the manufacture of larger products.

Both types of cobs are hollow and are fitted on the ends of metal bolts. When so fitted on a metal bolt the combination is termed a steel insulator pin as contrasted with the wooden insulator pin which has no metal in its make-up.

Black locust is well fitted for insulator pins because of its strength, durability, and freedom from excessive swelling and shrinking. Durable pins obviate the necessity of replacement at frequent intervals, a costly process in view of the difficulty of removing the wires

and insulators high up on the poles. Resisting swelling and shrinkage as they do with changes in the weather, locust pins tend to stay tight in the cross arms.

The estimated production of 25,000,000 black locust insulator pins in 1925 represents an increase of approximately 91 per cent above the 13,062,924 locust pins reported purchased in 1909. No statistics for the intervening years are available.

In 1909, 2,193,038 of the 15,807,804 insulator pins reported purchased were elm, and 551,842 were Osage-orange. The elm and Osage-orange together represented 17 per cent of the pins for that year. At present there is only a negligible quantity of elm and Osage-orange used. The wood of one of the eucalypts, blue gum (*Eucalyptus globulus*), trees grown in California is now used for approximately 1,250,000 pins annually. Eighty-five per cent of these pins are of the standard 8 and 9 inch sizes, and 15 per cent are of special sizes. Although blue gum shrinks and swells more than black locust and is not so durable, it appears to be satisfactory for pins under the conditions in which it has been used in California.

The average cost of locust insulator pins reported purchased by telephone and telegraph companies in 1909 was $12 per thousand. In the spring of 1926, telephone companies were paying $20 to $23 per thousand for the very best grade of locust insulator pins, an increase of approximately 80 per cent.

Both bolts and flitches of black locust are purchased for the manufacture of insulator pins. When bolts are used, one of two common methods of cutting them up to make squares for the pins may be employed. The first method consists in sawing the bolts into flitches on a short-log or bolter mill, and then running the flitches through a ripsaw to get squares of the required sizes. These long squares are crosscut to the desired length of the pin, 8 inches for the telephone pin and 9 inches for the electric-light pin, the obviously defective squares being thrown out. The short squares are put on automatic lathes, turned in the green state to the dimensions required, and the thread is either cut simultaneously on the same lathe or later on a separate lathe.

In the second method, instead of cutting flitches, the bolts are crosscut into sections the required length of the pins. From time to time a wedge-shaped piece may be cut when bolts are crooked to keep the sections right angled or square ended. A maximum of straight-grained material is said to be thus secured. The sections are sawed into pieces, and these in turn are ripped into squares. The process of turning and threading the pins is the same as in the first method.

Insulator pins of 8-inch length, the standard for most signaling lines, are given the following grades by the Western Electric Co.:

1. No. 1 (permits minor defects so located that the strength and durability of the pin are not affected).
2. "Standard commercial" or No. 2 (selected from pins not good enough to meet the requirements of No. 1).
3. Culls (permits wormholes, decay, or defective manufacture, but not such as to make the pin worthless.

Ordinarily 1,500 to 1,800 of the 8-inch telephone pins can be obtained from a cord of good wood, from 1,200 to 1,500 of the 9-inch

electric-light pins, and still fewer of the larger pins. The yields in pins of different grades to be obtained from large clear bolts and from smaller and inferior bolts are given in Table 5.

TABLE 5.—*Relative yield by grades of 8-inch telephone pins from large and small bolts*

Size of bolt	Grade 1	Grade 2	Grade 3
	Per cent	*Per cent*	*Per cent*
7 inches in diameter and up, with few defects	70	20	10
Less than 7 inches in diameter, with more defects	50	35	15

The lower yield of No. 1 pins from the smaller and more defective wood is, of course, to be expected. For pin purposes the quality of wood in the average stand of black locust in coves and on lower moist slopes is higher than in stands on comparatively dry upper slopes or in the very wet bottom lands.

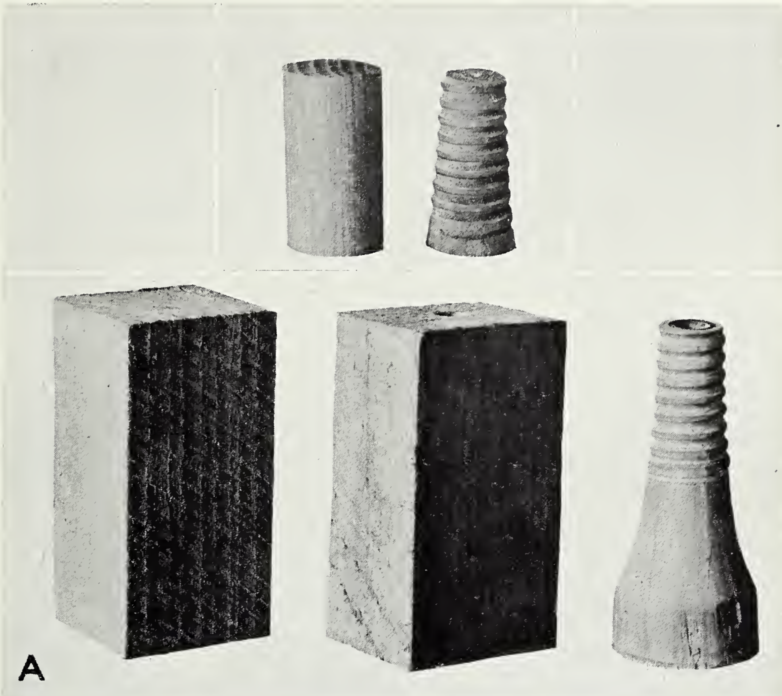
Insulator pins are usually shipped in burlap bags. Small bags which can be handled by one man are more convenient than the larger bags which require two men. The ordinary small burlap bag will hold the following numbers of the various types of insulator pins and cobs:

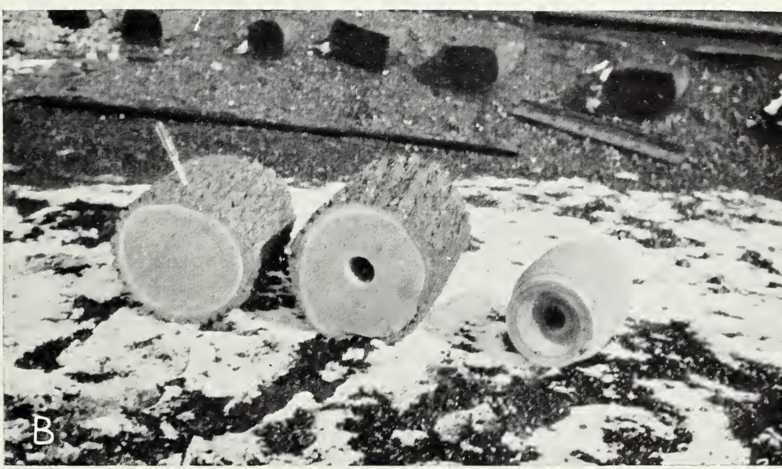
⅝ by 8-inch telephone pins	250
¾ by 9-inch electric-light pins	200
¾ by 12-inch duplex pins	150
¼ by 3½-inch cobs	1,000

Manufacturers are ordinarily able to obtain only 1 car of finished locust insulator pins from every 6 cars of locust bolts. In other words, considering the stacked bolts and loosely bagged pins have the same waste space, less than 20 per cent of the volume of the wood appears in the form of accepted insulator pins, the remainder being lost as bark, sapwood, sawdust, turnings, or defective heartwood. Some of the waste is used at the mill for fuel, some is burned in the refuse pile, and some is sold locally for fuel.

Manufacturers state that they about "break even" in manufacturing pins from bolts 5 to 7 inches in diameter and begin to profit on material 8 inches and up in diameter. Much of the 5 and 7 inch material is obtained for trees of that diameter. The practice of cutting 5 to 7 inch trees for insulator pins is not only an expensive and wasteful one in itself, but it destroys a great deal of young timber which, if left standing a few years longer, would reach a satisfactory size for pins. The most progressive pin manufacturers are refusing to accept bolts of the smaller diameters, thereby not only avoiding much waste in cutting up the material but discouraging farmers and wood-lot owners from cutting trees which have not reached the proper size for insulator pins.

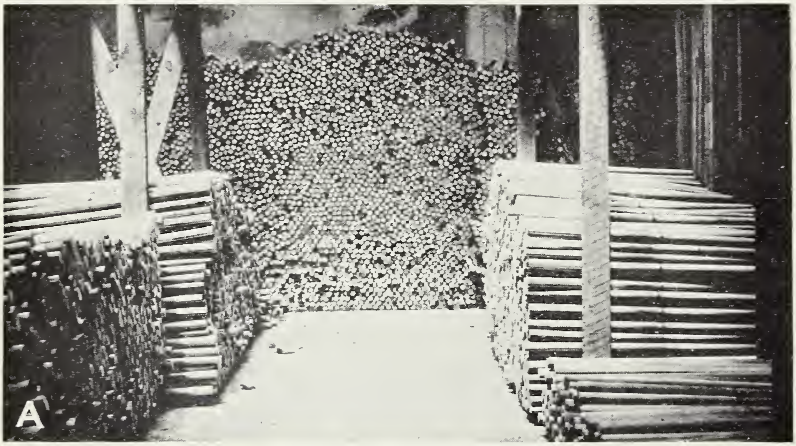
Much of the waste at mills manufacturing locust insulator pins is suitable for the handles of small tools such as chisels, screwdrivers, and gouges for which much less desirable woods are often employed. The strength and hardness of locust and its resistance to brooming make it able to withstand the rough treatment to which tool handles are often necessarily subjected. In Europe black locust is used with entire satisfaction for a wide variety of tool handles.





F206722

A, Stages in the manufacture of two types of cobs or tops. The upper type is made of locust only when waste is available. The lower type is always made of locust. The squares are approximately 2¼ by 2¼ by 4¾ inches; B, stages in the manufacture of a wagon hub from black locust



F204217 34048A

TREENAILS STILL FIND A USE IN WOODEN SHIPS

A, Finished treenails (long-length) in storage; B, driven and partly driven treenails in the hull of a wooden vessel.

WAGON HUBS

About 1,000 cords of black locust are used in the United States each year for wagon hubs. Bolts 9 inches and over in diameter of best-quality wood are required, and the supply is not equal to the demand. Black locust makes excellent hubs because of its strength, durability, and moderately small swelling and shrinkage. The freedom from severe swelling and shrinking makes locust hubs suitable for such varying moisture conditions as are found in the Mississippi River bottom lands and swamps where log wagons are used to remove the timber. Locust hubs also give satisfaction in dry climates such as those of Mexico and southwestern United States.

The process of making wagon hubs is simple. Bolts in lengths of 4 to 8 feet and in diameters 9 inches or above at the small end inside the bark are crosscut into sections the length of the desired hub. A hole is bored through the section, and the bored section is turned on a lathe to the rough shape of the hub. (Pl. 4, B) Slots for spokes are then mortised in the hub, and the mortised hub is allowed to season in an open shed from six months to a year. In order to reduce the moisture content below 12 to 15 per cent, it is necessary to dry the hubs artificially. When the proper moisture content is reached, the spokes are inserted, metal hub bands are attached, and the wheel is ready to be completed.

Occasionally manufacturers will cut into spokes locust bolts not suitable for hubs. Locust is very satisfactory for spokes and is employed in Europe for this purpose. A locust spoke, however, according to wheelwrights, will not grip as tightly in a locust hub as it will in a hub of another species. Hickory or oak spokes in a locust hub make a very tight joint that does not "cry" if the manufacturing is correct and the moisture conditions are not unusual.

The hub industry is a good illustration of the very common American practice of substituting a less desirable wood because of the scarcity of the more desirable wood. More high-grade locust can and should be grown in order to satisfy the needs of the hub manufacturer, who, incidentally, is quite willing to pay well for good material.

TREENAILS

As early as 1716 black locust from Virginia was in demand for ships. In 1812, 100,000 treenails or trunnels, the name given to long, slender, round pieces of hardwoods used for pinning ship timbers together (pl. 5, B), were cut in Pennsylvania and shipped to England. American frigates in the War of 1812 not only contained black locust treenails but black locust planking, stanchions, martingales, braces, posts, ribs, knees, and tillers.

Although very few wooden ships are being built at present, there is occasional demand for treenails.

Prior to the World War there were produced in the United States less than 300,000 treenails a year, requiring about 750 cords of wood. During the war, when the construction of wooden ships expanded so greatly, an annual production of 10,000,000 treenails was planned but probably not reached. This was on the basis of 30,000 to 40,000 treenails for each wooden ship. The production of treenails, of course, fell off greatly after the war. Present annual production (1926) is estimated roughly at not more than 200,000 treenails.

The making of treenails is a very simple process requiring little equipment, but some skill and judgment. Logs or bolts are cut on a bolter saw into flitches $1\frac{1}{2}$ inches thick, or flitches of this thickness are purchased from lumber companies. The flitches are run through a ripsaw or gang saw, so that pieces $1\frac{1}{2}$ inches square are produced. The squares are then cut to the required length (22 to 52 inches) and turned to a diameter of $1\frac{1}{32}$ inches. (Pl. 5, A.) The squares are ordinarily turned on lathes while the wood is fresh and green, as black locust turns with difficulty when seasoned.

Sometimes the flitches are crosscut before they are ripped, the object being to eliminate unmerchantable material before cutting the squares. If this operation is performed by an experienced man, it is probably the best practice, but with the average workman it is of doubtful advantage, as much waste may result.

The small amount of shrinkage and expansion in black locust, its durability and high degree of strength and toughness combined with ability to endure driving make it a very suitable wood for treenails. Osage-orange and live oak are generally considered to rank next. It is possible that other American woods if creosoted to insure durability would prove satisfactory.

A study was made during the World War to determine the volume of treenail squares that could be obtained from an average cord of bolts. It was found that the average solid volume in finished treenail squares for each cord of bolts was 23.6 cubic feet. After final inspection at the shipyards the average cord probably represented not much over 20 cubic feet. By assuming that the average actual volume of a cord of black locust was 75 cubic feet (large straight bolts may yield 90 cubic feet, and small crooked bolts as low as 60 cubic feet), a loss of about 69 per cent occurred in cutting the squares. Between 5 and 10 per cent of this loss was in squares 8 inches long, a length suitable for insulator pins. An average of 150 pins could probably be obtained from a cord of black locust in addition to the 620 treenails, whose average length is 28.6 inches.

FENCE POSTS

The distribution of black locust is so widespread and its local use for posts so universal that only a rough estimate of the number used is possible. Such an estimate places the number of black locust posts used annually at 1,000,000, equivalent to approximately 20,000 cords.

Probably no native wood, unless it be Osage-orange, is superior to black locust for fence posts because of its lasting qualities, strength, and ability to hold nails and staples.

Data on the durability of black locust fence posts were collected by the Ohio Agricultural Experiment Station, Wooster, Ohio, and published in a bulletin of the station in June, 1910.[2] The majority of the fences examined were located in Ohio. A few were in Indiana, Illinois, Kansas, and Texas. These data are shown in Table 6 which is a rearrangement of the original table in the experiment station bulletin. In no case were less than 60 per cent of the posts sound, and in most cases the percentage was considerably higher

[2] CRUMLEY, J. J. THE RELATIVE DURABILITY OF POST TIMBERS. Ohio Agr. Exp. Sta. Bul. 219, p. 605–640, illus. 1910.

than this even though some of the posts had been in the ground 42 years.

Although the figures in the table appear to be high for the country as a whole, the large number of posts and fence lines examined in this experiment show rather definitely the lasting qualities of locust in Ohio and neighboring States.

TABLE 6.—*Durability of black locust fence posts*[1]

Number of years in the ground	Diameter of posts	Total number of posts	Sound posts	Rotten posts	Percentage of sound posts
	Inches	*Number*	*Number*	*Number*	*Per cent*
0.5	4–6	13	13	0	100
5	3–5	26	26	0	100
6	4–6	56	56	0	100
6.5	3–5	44	36	8	82
8	4–6	41	37	4	90
8	4–6	59	59	0	100
9	3–5	44	32	12	73
11	4–6	14	13	1	93
14	6–8	68	63	5	93
14	4–6	24	23	1	96
15	4–6	180	174	6	97
16	4–6	625	568	57	91
16	3.5–6	1,271	1,173	98	92
17	4–7	640	570	70	89
17	5	64	64	0	100
18	6–8	94	87	7	93
20	4–6	132	111	21	84
20	4–6	51	43	8	84
20	4–6	156	126	30	81
21	4–6	156	143	13	92
22	4–6	68	68	0	100
22	4–6	35	35	0	100
22	4–6	122	88	34	72
22	6–8	57	54	3	95
24	4–6	67	67	0	100
25	4–6	26	25	1	96
29	4–5	123	74	49	60
30	4–6	61	55	6	90
31	4–6	51	45	6	88
31	4–6	25	22	3	88
32	4–6	166	115	51	69
35	6–7	87	62	25	71
40	4–6	24	20	4	83
42	5–9	174	157	17	90
42	4–6	35	27	8	77

[1] Data for this table were taken from tests of 4,879 posts as recorded in Ohio Agricultural Experiment Station Bulletin 219.

The following statement about a cornfield in Ohio which was abandoned in 1893, and on which black locust grew up of itself, is of interest:

> The abandoned cornfield was clay soil, and after 22 years the locust with no expenses of cultivation was cut into fence posts and marketed in 1916. At that time it cost 6 cents to cut, haul, and put the posts on the car, one and one-half miles from the grove. The price received for the posts was 17 cents apiece, or a net return of 11 cents. Three thousand one hundred and eighty posts per acre were harvested with a return of $350 or $16 per acre per year, a very good profit for a clay knoll to yield.

This is not given as an average for Ohio, but shows the possibilities of black locust when it grows under favorable conditions. There were numerous other acres on this farm just as favorable to the growth of locust that produced nothing in the 22 years, simply because neither man nor nature planted anything of value on them.

The forestry department of the Ohio experiment station has numerous records of locust groves in different localities in the State

from which posts were cut and marketed. Most of these records show that in 1915 and 1916 when posts sold in quantity at 10 cents for firsts and 6 cents for seconds, an annual income of from $8 to $15 per acre was derived.

Large quantities of black locust were cut in Pennsylvania as early as 1808. Posts were shipped down the Susquehanna River to Chesapeake Bay from where they were sent to more southern sections. One record shows that posts from Pennsylvania sold in Baltimore at $4 per hundred or 4 cents apiece at that time. At present black locust fence posts cost as high as $1.25 apiece or $75 a hundred in the city of Baltimore.

MINE TIMBERS

Mine operators in the United States reported the use of 245,326 cubic feet (approximately 1,925 cords) of round locust timber during the year 1923. This is less than two-thirds of 1 per cent of the total consumption of all species for mine timbers. It was for use underground, largely in bituminous-coal mines.

Many mine owners have extensive land and timber holdings, large parts of which are not producing timber and in which erosion is often going on. In view of the demand for strong and durable mine timbers, these nonproducing areas would serve a much more useful purpose if utilized for growing black locust.

POLES

Of the 3,060,794 poles reported purchased in the United States in 1923, 1,797 were black locust, about one-twentieth of 1 per cent. Of the 3,738,740 wooden poles of all species reported purchased in 1909, 10,463 were black locust, about one-third of 1 per cent. Most of the black locust poles purchased in both 1923 and 1909 were small poles, less than 30 feet in length. The average cost of poles 20 to 29 feet in length reported in 1909 was $1.09 apiece, and in 1923, $2.66—almost two and one-half times as great.

The few black locust poles used by electric railroads, and light, power, telephone, and telegraph companies are purchased near the point of installation. They are not shipped long distances as are cedar, chestnut, yellow pine, and cypress poles.

A black locust pole, although strong and durable, is heavy and therefore difficult to erect, and the wood is so hard that climbing is difficult even with sharp spikes. Owners of locust timber of suitable size located near pole lines may find it profitable to deal in the smaller sizes of poles, but black locust plays only a very small part in this industry. Locust timber of pole size is generally more valuable for insulator pins or wagon hubs.

MINOR USES

In addition to insulator pins, wagon hubs, treenails, fence posts, mine timbers, and poles, black locust is used in this country locally to some extent for crossties on small branch railroads where timber of proper size is available. Here, again, durability and resistance to mechanical wear make it a satisfactory wood, but the driving of spikes into locust is difficult. The chief drawback to its use for ties

is its high cost. Locust timber large enough and of good enough quality for crossties is generally more valuable for insulator pins or wagon hubs. Small quantities of black locust are used for mine sprags and wood screws, such as those in carpenter's clamps.

In Europe, where it was introduced from North America in 1635, locust suffers little damage from the locust borer, and the wood finds commercial use not only for the products common in the United States but for spokes, shafts, and other parts of carriages and light vehicles as a substitute for ash, handles for agricultural implements such as plows and cultivators, ladder rungs, vine stakes, and hop poles. It is also used in Europe for ax, pick, and other similar tool handles, fence pickets, screw plugs for railway-tie spikes, rake and harrow teeth, lath, toys, stopcocks, table legs, chair rungs and other turnery, gear teeth, tiller arms, stanchions, and pulleys. Where the timber is large enough it is occasionally used for clapboards.

Black locust handles for axes, picks, and such tools in Europe are admittedly not as strong as hickory handles used in similar tools in this country. The wood does not withstand shock as does hickory, but in the hands of the average European laborer, who is inclined to be more careful with his tools than is the average American laborer, good service is secured from black locust.

SUMMARY

Black locust trees of high quality and large size are becoming scarcer in the United States each year. Although there is no danger of the supply of black locust giving out at the present rate of consumption, users of the wood, particularly for insulator pins, are being forced to buy smaller and more defective material than in the past. Considerable waste of effort and material in cutting small and defective trees is the result. The cost of cutting, hauling, and handling small material both in the woods and at the mill is higher than for large material, and a greater percentage of the volume of the log is lost in sawing up bolts from small trees.

The ideal method of cutting black locust in the forest is to take the largest and the most available wood for insulator pins and wagon hubs, and the defective material for fence posts. It is false forest economy to cut small material for pins and hubs. The more progressive pin manufacturers are refusing to accept material less than 7 and 8 inches at the small end and are advising the farmers from whom they purchase the bolts to leave the small material standing until above 7 inches in diameter. The price per piece for large clear material is considerably higher than that for small material. The wood put on by the tree after it has reached fence-post size and freed itself of lower limbs generally contains fewer defects, and the danger from the locust borer after trees have reached a diameter of 5 or 6 inches is greatly lessened.

At the insulator-pin mills there is room for improvement in cutting up the material, in storing locust bolts, and in stacking locust flitches. The loss through checking of locust bolts and flitches and the warping and twisting of flitches through improper storage while waiting to be cut up is large. Much loss from checking can be avoided by coating the ends of locust bolts with a paint or other material that will prevent the rapid loss of moisture.

The high degree of strength, toughness, hardness, and durability of black locust and its moderate shrinkage and swelling give the wood a high rank for special uses where such properties are needed. Its ability to grow vigorously and rapidly when young under a wide range of soil and climatic conditions, combined with abundant reproduction by seeds and by stump and root sprouts, makes the tree valuable for checking erosion on denuded slopes. The locust borer is the most serious drawback to a wider use of both the tree and the wood.

APPENDIX

SPECIFICATIONS FOR INSULATOR PINS

Specifications for the 8-inch wooden insulator pin (fig. 2) prepared by the American Telephone & Telegraph Co. and in use in 1926, are as follows:

The 8-inch pin is intended for use with toll-line insulators, exchange-line insulators, and double petticoated insulators.

Wormholes.—Pins otherwise sound may contain a few wormholes or channels, provided that the diameters of the holes or channels are not greater than three-sixteenths of an inch; that the distances between the centers of holes of maximum diameter or groups of holes of equivalent area to a hole of maximum diameter is not less than 3 inches measured along the surface of the pin; that when holes are located above the plane of A, they do not materially decrease the resistance of the screw thread to the pulling off of a standard insulator; and that when holes are located between planes C and D, they will not interfere with the secure attachment of the pin to a standard cross arm, the attachment being made by a nail driven through the side of the cross arm and the shank of the pin.

Checks.—Pins may contain checks not over 2 inches in length provided that when they intersect either end surface, their depth measured on that surface shall not exceed one-eighth of an inch, and not more than one check shall appear on the same or nearly the same line of grain.

Seasoning.—Pins shall be thoroughly air seasoned. Pins seasoned by steaming or by boiling in water shall not be accepted.

MATERIAL

General.—The pins shall be made of sound straight-grained yellow or black locust, or Osage-orange (Bois d'Arc) free from knots, checks, sapwood, wormholes, brashy wood, cracks, and other defects except as hereinafter specified.

Grain.—The angle between the grain and the axis of the pin shall not exceed 5°, except that irregularities in the grain which are wholly confined to the section of the pin below the horizontal plane shown at D on the drawing (fig. 2), and local deviations in the direction of the grain due to the presence in the pins of knots hereinafter classed as acceptable, are permitted.

Sapwood.—Sapwood is allowable on the shoulder of the pins provided it does not extend into the shank.

Knots.—Pins shall be free from loose or unsound knots.

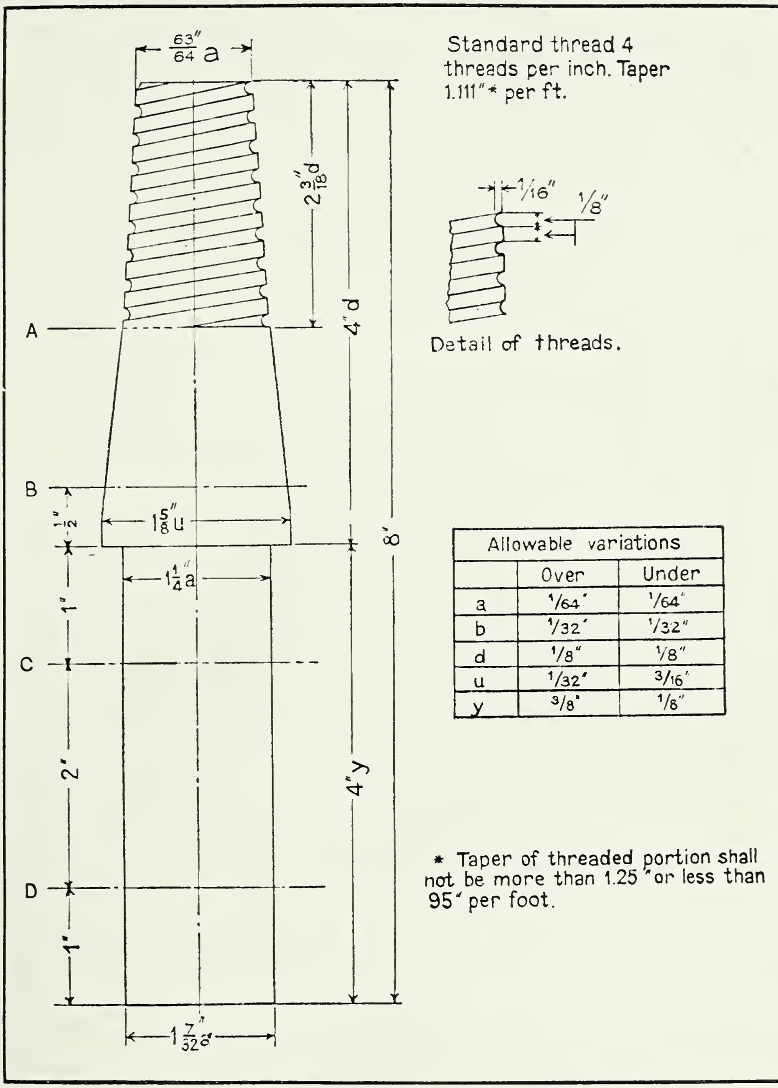
Sound knots not exceeding the limits given in the following table for the section of pins in which they occur are permissible:

Section of pin:	Maximum diameter of knot, inches
Between top of pin and bottom of shoulder	$\frac{5}{16}$
Between bottom of shoulder and horizontal plane at C	0
Between horizontal planes at C and D	$\frac{3}{8}$
Between horizontal plane at D and bottom of pin	$\frac{3}{4}$

When more than one knot hereinbefore permitted appears in a pin, the distance between the centers of the knots measured on the surface of the pin shall not be less than 1½ inches.

DIMENSIONS

General.—The seasoned pins shall be of the dimensions shown on the drawing. Where maximum and minimum dimensions are shown or indicated by allowable variations, the dimensions shall be within the limits specified. Where limits are not shown the dimensions shall show reasonable correspondence to



Allowable variations		
	Over	Under
a	1/64"	1/64"
b	1/32"	1/32"
d	1/8"	1/8"
u	1/32"	3/16"
y	3/8"	1/8"

FIGURE 2.—Dimensions of the 8-inch wooden insulator pin used by a large telegraph and telephone company

the stated figures. Figures on the drawing shall be followed in preference to scale measurements.

The pins shall be as nearly as possible of a circular cross section. The top sections of the pins shall have single threads of four revolutions to the inch.

The thread shall be smooth, of uniform pitch and of the shape shown on the drawing.

Shape and finish.—The following deviations from the drawing shall be permitted provided that they do not appear on more than 20 per cent of the pins furnished: (1) Flat surfaces on the shoulder, provided that the wood is not cut away to such a depth as to eliminate the bottom surface of the shoulder at any point on the circumference; and (2) any irregularity in shape between the horizontal plane at D and the bottom of the pin which does not involve the removal of more than one-third of the cross section of the pin called for in the drawing.

SPECIFICATIONS FOR TREENAILS

At the beginning of the war only small quantities of treenails were being produced by a few manufacturers. The construction of large numbers of wooden vessels during the war caused a sudden demand for treenails greatly in excess of the capacity of existing plants. Many people undertook the manufacture of treenails who were unfamiliar with the properties of black locust and found considerable difficulty in turning out an acceptable product. In June, 1918, a treenail association was formed at Philadelphia, which, in cooperation with the Emergency Fleet Corporation and the Forest Service, was able to stabilize the suddenly expanded industry. The Forest Service prepared for the Emergency Fleet Corporation a set of specifications for treenails which were widely used.

The specifications prepared at that time and at present applicable for treenail squares and turned treenails are as follows. Live oak and Osage-orange as well as black locust were allowed, but by far the greater number of treenails were made from black locust.

TREENAIL SQUARES

Material

To be black or yellow locust (*Robinia pseudoacacia*), live oak (*Quercus virginiana*), or Osage-orange (*Toxylon pomiferum*). All squares to be entirely free of spike knots, knots in clusters, and to be sound (sound material excludes squares containing wormholes which can not be removed in turning, any form of rot or decay, powder post, and encased bark), except for the following defects, which are allowed:

(1) Sound knots, the aggregate diameter of which does not exceed one-half inch in each and every 12 inches of length, provided no knot is larger than one-fourth of an inch in average diameter and no ¼-inch knot is closer than 2 inches to any other knot.

(2) Cross or spiral grain not exceeding in slope more than 1 inch in a length of 20 inches.

(3) Season checks, splits, and shakes extending into the treenail for a distance not exceeding 1 inch on each end.

(4) Sap on one end not exceeding one-fourth of an inch in thickness on any face or three-eighths of an inch on any corner for a distance of not more than one-fourth of an inch of the length of the piece.

(Sap, in addition to that allowed in item 4, wane, surface wormholes, or similar defects which, in the judgment of the inspector, can be removed in turning the treenail will also be allowed. Iron streaks will not be considered defects).

Size

Squares to be cut to sizes specified, allowing one-sixteenth of an inch variation in thickness and width and one-half inch in length.

Finish

All squares to be rough sawn.

TURNED TREENAILS

Material

To be thoroughly seasoned (approximately 15 per cent moisture) black or yellow locust (*Robinia pseudoacacia*), live oak (*Quercus virginiana*), or Osage-orange (*Toxylon pomiferum*). All treenails to be entirely free of spike knots, knots in clusters, and to be sound. All treenails to be entirely of heartwood, except as allowed below. The following defects are allowed:

(1) Sound knots, the aggregate diameter of which does not exceed one-half inch in each and every 12 inches of length, provided no knot is larger than one-fourth of an inch in average diameter and no ¼-inch knot is closer than 2 inches to any other knot.

(2) Cross or spiral grain with a slope not exceeding 1 inch in a length of 20 inches.

(3) Season checks, splits, and shakes extending into the treenail for a distance not exceeding 1 inch on each end.

(4) Sap not exceeding one-eighth of an inch in thickness nor more than one-fourth the length of the treenail on the pointed end only.

(Iron streaks will not be considered a defect. Dips in the grain, which at the maximum slope do not exceed the allowable cross grain, will be permitted.)

Size

Treenails to be turned to sizes specified, allowing one-half inch variation in length.

Shape

Treenails to be tapered or drift turned. When drift turned, each drift to occupy one-half the length of the treenail with one-sixteenth of an inch difference in diameter between drifts. When tapered the difference in diameter between the small and large end to be one-sixteenth of an inch.

Finish

Treenails to be smoothly turned and to have points tapered for a length of about three-sixteenths of an inch to about a 30° bevel at the pointed end. No treenails with flat faces will be accepted.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	ARTHUR M. HYDE.
Assistant Secretary	R. W. DUNLAP.
Director of Scientific Work	A. F. WOODS.
Director of Regulatory Work	WALTER G. CAMPBELL.
Director of Extension Work	C. W. WARBURTON.
Director of Personnel and Business Administration.	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Solicitor	E. L. MARSHALL.
Weather Bureau	CHARLES F. MARVIN, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Forest Service	R. Y. STUART, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Bureau of Entomology	C. L. MARLATT, *Chief.*
Bureau of Biological Survey	PAUL G. REDINGTON, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Bureau of Agricultural Economics	NILS A. OLSEN, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Plant Quarantine and Control Administration	LEE A. STRONG, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Director of Regulatory Work, in Charge.*
Office of Experiment Stations	————, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*

This circular is a contribution from

Forest Service	R. Y. STUART, *Chief.*
Branch of Research	EARLE H. CLAPP, *Assistant Forester, in charge.*
Division of Forest Products	H. S. BETTS, *in Charge.*

U. S. GOVERNMENT PRINTING OFFICE: 1930

For sale by the Superintendent of Documents, Washington, D. C. - - - - Price 10 cents